Table of Contents: Supplemental Digital Appendixes

Supplemental Digital Appendix 1
Identification of Quality Measures

We identified quality measures for analysis via a multi-step procedure. First, we reviewed nationally recognized[1] quality measures pertinent to psychiatrists or neurologists including those in guidelines (i.e., recommended practices), standards (i.e., required activities), and evidence-based procedures (i.e., those known to have favorable impact on patient outcomes) from numerous sources including accrediting bodies[2,3], Federal agencies[4,5,6], national entities[7,8,9], physician organizations[10-13], research institutes[14-20], and review articles[21,22].

Measurement inclusion criteria emphasized "feasibility"[23] for extraction from electronic claims databases. Exclusion criteria were measures based on health record narrative[11,12] not likely to be found in claims, lack of specification for numerators or denominators[13], as well as measures with likely ceiling or floor effects.

We examined in detail performance measures in the Physician Quality Reporting System (PQRS) from the Centers for Medicare and Medicaid Services[4]. However, as noted by Berenson and Kaye[24] "less than 30% of eligible professionals report their data to CMS (Centers for Medicare and Medicaid Services)" whose "available measures in the PQRS and elsewhere are relevant to few of these professional qualities".

Second, we chose patient populations (defined by diagnoses) for whom care guidelines existed whose performance metrics were (at least potentially) available in administrative claims data. For psychiatrists, we identified as the population of interest people with schizophrenia treated as outpatients with atypical (second generation) anti-psychotic medications. Potentially available quality measures addressing glycemic assessment, lipid assessment, duration of treatment, and anti-psychotic poly-pharmacy avoidance have been endorsed by several organizations.

For neurologists, we identified two populations of interest – namely, hospital inpatients with principal diagnosis of ischemic stroke and outpatients with atrial fibrillation. Potentially available quality measures pertaining to treatment of people with ischemic stroke that have been provided by several organizations include carotid imaging reports (for stenosis measurement), computerized tomography or magnetic resonance imaging reports (pertaining to hemorrhage, mass, and-or acute infarct), consideration of tissue Plasminogen Activator (t-PA), deep vein thrombosis prophylaxis, screening for dysphagia, consideration of rehabilitation services, assessment for rehabilitation, progress (i.e., improvement) in functional communication (writing, swallowing, expression, comprehension, reading, speech, memory, attention), acute stroke mortality rate, and avoidance of intravenous heparin. For people with atrial fibrillation, potential measures included anti-platelet therapy and anticoagulant therapy. Notice that deep vein thrombosis prophylaxis and anti-coagulation for patients with atrial fibrillation are considered standards of care.

Third, we conducted preliminary analyses of the electronic claims data in order to assess measurement feasibility. We located (in commercial fee-for-service claims data) patients with diagnoses of interest (schizophrenia, stroke, and atrial fibrillation, respectively) treated by psychiatrists or neurologists. Then, we assessed performance measure feasibility. All psychiatry quality measures were retained. However, several neurology measures pertaining to ischemic stroke

inpatients were excluded due to ceiling or floor effects (e.g., orders for computerized tomography or magnetic resonance imaging) or requirements for narrative documentation review (e.g., imaging reports, consideration of tissue Plasminogen Activator, consideration of rehabilitation services, assessment for rehabilitation, progress in functional communication). As described below, we also excluded (at the preliminary analysis stage) outpatient treatment by neurologists for people with atrial fibrillation.

Supplemental Digital Appendix 2
Physician Matching

Physician identifiers including National Provider Identifier (NPI)[25], first name, last name, state, city, and street number were provided to HealthCore staff who were blinded with respect to board certification status. Blinded staff then conducted the linkage hierarchically as follows:

Step 1 - Matched on exact NPI, first name and last name
Step 2 - Matched on exact first name, last name, city, state and street number
Step 3 - Matched on exact NPI and last name
Step 4 - Matched on exact NPI
Step 5 - Matched on exact first name, last name, state and street number
Step 6 - Matched on exact first initial, last name, state and street number

Using National Provider Identifier, first name, and last name there were exact matches to the claims data for 842 board certified psychiatrists, 751 not board certified psychiatrists, 872 board certified neurologists, and 301 not board certified neurologists. Final matching on combinations of National Provider Identifier, first and last name, state, street number, and first initial yielded matches for 942 board certified psychiatrists (94.2% of the1,000 board certified psychiatrists), 963 board certified neurologists (96.3% of the 1,000 board certified neurologists), 868 not board certified psychiatrists (86.8% of the 1,000 not board certified psychiatrists), and 328 not board certified neurologists (89.6% of the 366 not board certified neurologists).

Supplemental Digital Appendix 3
Medication Possession Ratio

Medication possession ratio (MPR) between first anti-psychotic fill and end of follow-up was the sum of days with any medication on hand (fill date through fill date plus days supplied) divided by days of follow-up. Because patients switching anti-psychotics or experiencing emergencies might have had medication overlap, we constructed multi-drug day categorical variables (using cut-points between 10% and 25%).

Supplemental Digital Appendix 4
Inpatient and Outpatient Claims for Patients of Neurologists

Claims typically contain limited information about hospital drug use because inpatient medications are often lumped together and billed under a pharmacy revenue code. Therefore, we used outpatient medication fills within the first 30 days following discharge as proxies for inpatient medications (and similarly for barium swallows and speech pathology consultations). We did not analyze claims for aspirin (typically obtained over the counter).

Supplemental Digital Appendix 5
Multi-level Model Results

Predictor	Odds ratio	Confidence interval (95%)
Psychiatrists treating patients with schizophrenia – glucose test		
Patient gender (female)	1.24	(1.00, 1.53)
Patient age	1.01	(1.00, 1.02)
Physician gender (female)	0.85	(0.65, 1.10)
Physician age	1.00	(0.97, 1.02)
Years in practice	1.00	(0.98, 1.02)
Board certification	1.19	(0.96, 1.49)
Psychiatrists treating patients with schizophrenia – lipid test		
Patient gender (female)	1.06	(0.86, 1.32)
Patient age	1.02	(1.01, 1.03)
Physician gender (female)	0.94	(0.71, 1.24)
Physician age	0.99	(0.97, 1.02)
Years in practice	1.01	(0.99, 1.03)
Board certification	1.24	(0.99, 1.55)
Neurologists treating patients with ischemic stroke – inpatient dysphagia evaluation		
Patient gender (female)	0.78	(0.69, 0.88)
Patient age	1.02	(1.02, 1.03)
Physician gender (female)	0.95	(0.80, 1.13)
Physician age	1.00	(0.98, 1.02)
Years in practice	1.00	(0.99, 1.02)
Board certification	1.06	(0.89, 1.25)

Supplemental Digital Appendix 6
Log Likelihood Increases

	Glucose testing for psychiatrists' patients with schizophrenia	Lipid testing for psychiatrists' patients with schizophrenia	Dysphagia evaluation for neurologists' inpatients with ischemic stroke
Total sample size	1,587	1,587	14,784
Complete data sample size	1,555	1,555	14,476
Complete data events	899	584	1,220
Log likelihood without predictors (null model)	–1,058.78	–1,029.18	–4,184.92
Log likelihood with patient only predictors	–1,050.00	–1,011.39	–4,125.19
Log likelihood with patient and physician predictors	–1,049.12	–1,009.99	–4,125.02
Log likelihood increase with patient and physician predictors	9.66	19.19	59.90
Log likelihood increase with patient only predictors	8.78	17.79	59.74
Percent log likelihood increase due to physician predictors	9.1%	7.3%	0.3%

Supplemental Digital Appendix 7
Universes of Physicians

In November of 2012 some 47,282 psychiatrists practiced in the United States[26]. American Board of Psychiatry and Neurology records in October of 2012 showed 36,095 board certified psychiatrists under age 70 and not known to be dead suggesting there were more than 11,000 not certified psychiatrists nationally.

Including residents and fellows, there are roughly 16,366 currently practicing neurologists in the United States[27]. In October of 2012, the American Board of Psychiatry and Neurology showed 15,056 board certified neurologists under age 70 and not known to be dead which suggests there were roughly 1,000 not certified neurologists nationally. Consequently, the study had substantial numbers of board certified neurologists but modest numbers of the not certified.

Supplemental Digital Appendix 8
Atrial Fibrillation Quality Measures Preliminary Analyses

Preliminary analyses involved patients with diagnosis of atrial fibrillation in any setting seen by a neurologist linked to the claims data (2006 through 2012). We identified the service date of the first claim with a diagnosis of atrial fibrillation submitted by a linked neurologist as the index date. Quality measures were prescriptions for warfarin or for a Factor Xa inhibitor including apixaban, betrixaban, edoxaban, otamixaban, and rivaroxaban.

There were 215 board certified (75.8% male) and 60 not board certified (78.3% male) neurologists with atrial fibrillation patients. Neurologists' average ages were 55.0 (standard deviation 8.9) and 55.2 (standard deviation 9.5) while years in practice were 21.4 (standard deviation 9.8) and 21.2 (standard deviation 12.0) with no statistically significant differences between groups. There were 836 patients (52.0% female) of board certified neurologists and 318 patients (51.3% female) of not board certified neurologists. The mean age for the board certified neurologists' patients was 75.5 years (standard deviation 12.3 years) versus 67.9 years (standard deviation 17.4 years) for the not board-certified neurologists' patients (*P* less than .001).

Preliminary analyses showed that patients with atrial fibrillation saw neurologists subsequent to stroke or transient ischemic event. Indeed, we found that some 55% of patients had been diagnosed with atrial fibrillation more than a year prior to the first claim from a neurologist. Approximately 70% of patients who saw a neurologist with a diagnosis of atrial fibrillation had an ischemic stroke diagnosis before or on the same claim date as the first claim with a neurologist.

Thus, it appeared misleading to use the first neurology claim as an anchor to examine treatment for patients with atrial fibrillation because the initial management and much of the ongoing management of atrial fibrillation likely preceded the involvement of a neurologist. Also, there were modest (1,154) numbers of atrial fibrillation patients who may not be representative of patients being diagnosed and treated for atrial fibrillation. In addition, patients with atrial fibrillation seeing board certified versus non-board certified neurologists differed markedly with respect to age and likely on other (potentially unmeasured) factors that may confound results. Therefore, we discontinued analyses of patients with atrial fibrillation.

Supplemental Digital Appendix 9
Medicare Physician Quality Reporting System

In Medicare's Physician Quality Reporting System providers use claims forms to submit data on numerators and denominators pertaining to quality of care measures. Unfortunately, the procedure is sufficiently complicated that some four pages are needed to address submissions regarding dilated macular examination of patients with diabetes[28]. Moreover, psychiatrist and neurologist participation remains to be seen[29]. Nonetheless, the vision statement for the system includes "outcome measures such as those that look at the rate of improvement over time"[30]. And, there have recently been calls for "routine use of functional outcome measures"[31]. On the other hand, outcome analyses must contend with large variances among patients thanks to multiple determinants of health including patient, environment, system, and clinician factors[32] such that "physicians rarely account for more than 4% of the variation in common (outcome) profile measures"[33].

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